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(54) A BLADE CARRYING DISC FOR A GAS TURBINE ENGINE

(71) We, ROLLS-ROYCE LIMITED, a British Company of 65 Buckingham Gate, London, SW1E 6AT, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement.

This invention relates to a blade carrying disc for a gas turbine engine.

In gas turbine engines, the various rotor blades are normally carried by a disc of discs which are so dimensioned to enable them to carry the centrifugal loads from the blades. This often necessitates the discs being made very thick at their centre, which is normally provided with a central aperture or bore. The difference in thermal inertia between this thick central portion and the relatively thin outer portion causes differential expansion and thermal stresses which may adversely affect the life of the disc. The thin parts of the disc, because they heat up quickly, also expand quickly and this may make it difficult to ensure that the clearance between the blade tips and associated static structure is maintained. Various cooling systems have been proposed in the past to cool the thin portions of the disc but hitherto these have been relatively heavy and complicated.

The present invention provides a disc having means for reducing the temperature differential in the material of which it is made.

According to the present invention, a blade-carrying disc for a gas turbine engine has at least part of its surface covered with a coating of a heat insulating material.

Where said disc comprises a relatively thin outer portion and a relatively thick inner portion, the coating is preferably applied in such a way as to reduce the heat input to and output from the relatively thin outer portion only.

Alternatively, or in combination, where two areas of the disc are subject to different ambient temperatures only the area of the disc surface subject to the higher temperature is provided with the heat insulating coating.

Sometimes such a disc is provided with a driving flange which may be intermediate the relatively thin and relatively thick portions and which may also separate the areas of different temperature, and it may be convenient to provide the insulating coating solely on those portions of the disc lying outside this driving flange.

The insulating coating preferably comprises a paint-like material which may consist of a binder within which are carried hollow particles of a material such as fly ash.

The invention is most effectively applied to the turbine rotor discs or high pressure compressor discs of a gas turbine engiine.

The invention will now be particularly described, merely by way of example, with reference to the accompanying drawings in which:-

Figure 1 is a partly broken away view of a gas turbine engine having discs in accordance with the invention, and

Figure 2 is an enlarged sectional view of the turbine rotor disc of Figure 1 in accordance with the invention.

In Figure 1 there is shown a gas turbine engine 10 comprising a casing 11 within which are mounted in flow series, a compressor 12, combustion system 13 and turbine 14 and which forms a final nozzle 15. Operation of the engine is conventional in that the compressor 12 takes in air which is compressed and mixed with fuel and burnt in the combustion chamber 13. Hot gases from the combustion chamber drive the turbine 14 which in turn drives the compressor 12, and waste gases from the turbine pass through the nozzle 15 to provide propulsive thrust.

The turbine 14 comprises an annular row of rotor blades 16 mounted from the periphery of a disc 17, the disc being provided with a driving flange 18 by which it is connected to a shaft 19 which transmits drive to the compressor.

Figure 2 shows in more detail the arrangement of the turbine disc 17. The disc is seen to comprise a relatively thin outer portion 20 which is provided with a local thickened portion at its periphery at 21 and is provided with grooves 22 within which the roots 23 of the blades 16 are supported. The grooves 22 are conveniently of the normal fir-tree or dovetail form, with the roots 23 being correspondingly shaped so that they locate within the grooves. When the disc 17 is rotating, the blades 16 and the mass of the disc itself causes considerable centrifugal loads to be exerted on the disc, and in order to allow it to sustain these loads, it is provided with a greatly thickened portion 24 at its radially inner portion surrounding a central bore 25. The portion 24 is much thicker than both the portions 20 and 21. In this particular instance, the disc 17 is connected to the shaft 19 which drives the compressor by way of a driving flange 18 which projects from the disc approximately at the junction between the thickened portion 24 and the thinner portion 20. Again in this instance, a similar but lighter flange 26 extends from the opposite face of the disc to carry the rotating portion 27 of a labyrinth seal.

It will be understood that in operation, hot gases impinge upon the blades 16 and cause these to become very hot.

In order to cool the blades, various cooling flows of air are provided which in terms of room temperature are still very hot, thus the temperature of this cooling air may be some 500°C. This air washes round the thin portions of the disc and heats it up, and this heating is reinforced by the conduction of heat from the hot blades through their roots and into the disc. There is therefore a considerable heat input to the outer portions of the disc.

It should also be noted that because of the rotation of the disc and the relative velocity between the disc surfaces and the surrounding air, the heat transfer coefficients toward the rim of the disc are higher than those toward the disc centre, an effect which is enhanced by the greater density of air in this region. This all has the effect of causing the thin outer portions of the disc to respond rapidly to changes in temperature in the various engine flows.

Because the thin portion has relatively low thermal inertia, it heats up relatively rapidly once the engine starts, and it will respond to changes in the engine operating conditions relatively quickly. However, the massive portion 24 has considerable thermal inertia and acts as a large heat sink; its temperature will vary only at a very slow rate in response to changes in engine operating conditions. The situation could therefore arise that the thinner portion differs considerably in temperature from the thicker portion, and that the thin portion changes rapidly in temperature, while being attached to the thick portion whose temperature is relatively steady. Therefore considerable thermal stresses could be caused in between the thick and thin portions.

Additionally, the rapid changes of temperature of the thin portions of the disc may cause correspondingly rapid expansion and contractions of the disc and thus of the blade tips, and it has been difficult in the past to arrange that the tip seals of the blades were able to follow these rapid thermal movements.

In order to reduce these differences in the disc shown in Figure 2, and the rapidity of the changes of dimension of the disc, a coating 28 is applied to both faces of the disc in the area where the disc is relatively thin, i.e. in the region 20. It happens that with the disc of the present embodiment, the flanges 18 and 26 extend from the disc in the transition region between these thick and thin areas which also coincides with the boundary between an area of hot gas, outside the flange, and an area of cool gas inside the flange. It is therefore convenient to apply the coating from the flanges 18 and 26 over the remaining outward radial extent of the disc.

It will be seen that the effect of this insulating coating is to reduce the amount of heat entering the disc from the surrounding air, at least in the thinner region 20, which in the present case coincides with the area of hotter gas. Therefore this thinner region is provided with a greater effective thermal inertia and the thermal stresses between the thin and thick portions are reduced, as are the thermal movements of the disc rim and blades.

In face we calculate that for the disc 17, having a coating 28 of 0.5 mm thickness and consisting of fly ash in a ceramic matrix, the difference between the rim and bore temperature is reduced by about 100° in 450° compared with an uncoated disc.

Clearly, the coating material which forms the coating 28 must satisfy a number of conditions. Thus it must have a low value of thermal conductivity or diffusivity, but must not detach easily from the disc material. A number of different materials could be used, but we prefer to use a paint-like composition comprising a suspension of particles of fly ash in a ceramic base or matrix. The particles of fly ash in fact comprise minute hollow spheres of glassy material. The

hollow spheres provide very low thermal conductivity, and therefore by providing a large number of these spheres, a low overall conductivity for the coating may be achieved. The coating may be applied by various of the conventional methods such as brushing, spraying, dipping or electrophresis.

A number of alternative compositions could be used but these mostly depend upon a matrix material within which is entrained a proportion of a heat insulating medium which may comprise air or another low conductivity material.

It will be understood that the disc of the present invention would be applicable not only to turbines but also to compressors, particularly the higher pressure stages of compressors. It should also be noted that although in the embodiment described the flanges 18 and 26 provide convenient inner extremities for the coated portion, it is not necessary that a disc possess these features to enable the present invention to be used. In fact the boundary of the coating may be arranged to coincide with a boundary between an area of hot gas and an area of cooler gas in contact with the disc, or it may be arranged to coincide with the boundary between thin and thick parts of the disc. In some cases these boundaries may coincide, and in some cases it may be convenient to arrange the boundary of the insulation in a different location.

WHAT WE CLAIM IS:-

1. A blade-carrying disc for a gas turbine engine, the disc having at least part of its surface covered with a coating of a heat insulating material.

2. A blade-carrying disc as claimed in claim 2 and in which said coating comprises a paint-like material.

3. A blade-carrying disc as claimed in claim 2 and in which said coating comprises a matrix within which is entrained heat insulating medium.

4. A blade-carrying disc as claimed in claim 3 and in which said coating comprises particles of fly ash suspended in a ceramic matrix.

5. A blade-carrying disc as claimed in any preceding claim and comprising a relatively thin outer portion and a relatively thick inner portion, the coating being applied in such a way as to reduce the heat input to and output from the relatively thin outer portion only.

6. A blade-carrying disc as claimed in claim 5 and in which the coating covers the majority of the relatively thin outer portion only.

7. A blade-carrying disc as claimed in any preceding claim and in which in use, two areas of the disc surface are subject to different ambient temperatures and only the area of the disc surface subject to the higher temperature is provided with the heat insulating coating.

8. A blade-carrying disc as claimed in any preceding claim and comprising an annular driving flange separating a outer and an inner portion, the insulating coating being applied to said outer portion only.

9. A blade-carrying disc as claimed in any preceding claim and comprising a turbine rotor disc.

10. A blade-carrying disc substantially as hereinbefore particularly described with reference to the accompanying drawings.

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Agent for the Applicants

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1556274 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig.1.

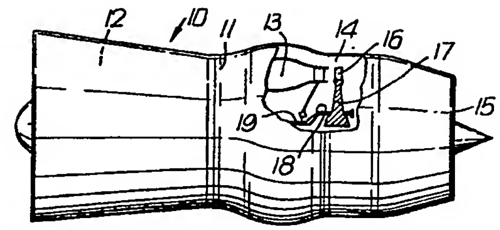

Fig.2.